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1. Title of the Invention

MANUFACTURING METHOD FOR LIQUID CRYSTAL DISPLAY DEVICE

2. Claims

1. A manufacturing method for a liquid crystal display device, characterized in that in a manufacturing process for a liquid crystal display device using a-Si TFT, in sticking a glass substrate where a-Si TFT and an ITO pixel electrode are disposed and a glass substrate where a color filter and an ITO counter electrode are disposed to each other through a fixed gap space, in a sealant on a wiring area for taking out a terminal, glass fiber is used as a spacer material, and a plastic spacer material having elasticity is used on a display screen area filled with liquid crystal.

2. The manufacturing method for a liquid crystal display device according to claim 1, wherein the plastic spacer material is spherical, and the plastic spacer material has the compressibility ranging from 10% to 20% when load of 20kg is applied in a temperature range from -30°C to 200°C.

3. The manufacturing method for a liquid crystal display device according to claim 1, wherein the plastic spacer material is a crosslinked copolymer mainly composed of di-vinyl benzene or a crosslinked copolymer mainly composed of benzoguanamine-formaldehyde condensation product.

4. The manufacturing method for a liquid crystal display device according to claim 1, wherein the dispersion density in a display screen area of the plastic spacer material ranges from 30/mm^2 to 150/mm^2, and the dispersion density in a sealant of the glass fiber spacer material ranges from 5 to 50/mm^2.

3. Detailed Description of the Invention

[Industrial Field of Application]

This invention relates to a manufacturing method for a liquid crystal display device and particularly to the manufacturing method for a liquid crystal display device suitable for preventing a TFT element from being damaged in sticking a TFT substrate and a common electrode substrate where a color filter is disposed to each other through a fixed gap space.

[Prior Art]

Generally, as a spacer material of an active matrix liquid crystal display panel, which is one of liquid crystal display devices, glass fiber having a designated diameter has been cut to a designated length to be used heretofore. At the time, as a basis for selection of spacer materials, it is the most important point that in heat bonding the upper plate and the lower plate by application of fixed load using a thermosetting sealant, the gap space will not become ununiform in the display screen because of thermal deformation. Accordingly, glass fiber hard to cause thermal deformation even if thermal load is applied has been mainly used as the spacer material. Recently, plastic hard superfine spheres have been developed and started using in some liquid crystal panels. The performance, reliability and the other problems are, however, quite unknown in the case of applying the above spheres to a large-area highly-integrated a-Si TFT active matrix liquid crystal panel. Further, as disclosed in JP-B-61-33166, a method of disposing a spacer in a place other than an electrode part using a mask corresponding to a pixel is also applicable to a simple matrix panel, which is simple in structure of one pixel and has a small number of pixels per area, but the application to the above active matrix panel is difficult.

Therefore, in the case of uniformly dispersing spacers at uniform density in the whole of the active matrix liquid crystal panel having the degree of integration of the pixels as much as 80,000 to 1,000,000, it has been necessary to develop a spacing method for the manufacturing method for a liquid crystal

display device, which does not cause failure such as gate-drain reduction due to damage of a-Si TFT even if a-Si TFT pattern for pixel selection set in each pixel and a spacer overlap each other.

[Problems that the Invention is to Solve]

Fig. 1 shows an example of a section of one pixel part of a transmission type a-Si TFT active matrix liquid crystal display panel according to the prior art. The panel has a sectional structure in which a translucent glass substrate 1 (a lower plate) where a-Si TFT and an ITO pixel electrode are arranged in each pixel and a translucent glass substrate 16 (an upper plate) where a color filter and a common electrode of an ITO corresponding to each pixel are arranged are stuck to each other at a desired gap space with a spacer material 12 such as glass fiber held between them to enclose liquid crystal 11. The a-Si TFT on the lower plate 1 is ordinarily composed of a Cr gate electrode (a scan line) 2, an SiN gate insulation film 3, a-Si:H (i) semiconductor 4, a drain electrode (a signal line) 5 formed of a Cr/Al two-layer film and a source electrode 6. An ITO pixel electrode 7 is electrically connected to the source electrode 6. An SiN protection film 8 and a shielding film 9 are sequentially formed on these patterns, and lastly an orientation film 10 is applied to form the lower substrate. On the other hand, a color filter layer 15, a filter protection film 14, an ITO common electrode 13, and an orientation film 10 are sequentially formed with one-to-one correspondence to the respective pixels on the upper plate 16. As described above, in sticking the upper and lower plates to each other, when a spacer material made of glass fiber is generally used in order to keep a gap between the upper and lower plates fixed, as shown in Fig. 1, a portion where the glass fiber gets over the a-Si TFT occurs at a certain probability. For example, when glass fibers are distributed at a density of $10/mm^2$ in a display screen, taking the size of one pixel as 200 μm x 200 μm, 25 pixels are existent in 1 mm^2. Therefore, when the area of a-Si TFT in one pixel is considered to be about 10% of one pixel at maximum, getting-over is caused at probability of one in 25 pixels.

When upper and lower plates are stuck to each other using a sealant,

thermal load about 1kg/cm^2 at 150°C is applied to form a gap. At the time, in the case where the above getting-over occurs, a great load is applied specifically to that part. Since the glass fiber has Mohs' hardness of 55, it is harder than the TFT element, and also the compressibility per 1kg/cm^2 is generally low as much as 2 to 3 x 10 $^{-6}$% so that deformation is hardly caused, the rate of occurrence of crushing of the TFT element becomes high.

For example, when the gate electrode (a scan line) and the drain electrode (a signal line) are short-circuited by crushing of the TFT, a defect (a linear defect) linearly extended from a short-circuited pixel part of the TFT is found in the liquid crystal display. Especially, in the active matrix liquid crystal panel using a-Si TFT, the a-Si film and the SiN film used as a gate insulation film are both hard and fragile, and also the projection of the TFT element part has a height about 0.5 to 1.5 μm, so especially the above crushing is easily caused. Further, the problem is that when electric short-circuit is once caused by crushing, breaking easily gets serious. The liquid crystal panel causing such defects can't be used as a panel for a display.

Then, a new sticking method has been needed to prevent breakage of the TFT caused by glass fiber occurring in the process of sticking the upper and lower plates to each other.

[Means for Solving the Problems]

In order to solve the problems, in the manufacturing method for a liquid crystal display device of the invention, as shown in Fig. 2, plastic spherical beads 26 having high compressibility and high thermal deformability are used on a display screen area 23 where a TFT element and cross-over wiring of a scan line and a signal line are disposed glass fibers 25 are dispersed in a sealant 24 for sticking an upper plate 21 and a lower plate 28 on an area 22 where a leading wiring is existing, and thermal load is applied to stick the plates to each other.

[Operation]

According to the method, the glass fiber 25 in the sealant having low compressibility and causing little thermal deformation and pressure deformation

is mainly in charge of forming the whole gap between the upper plate 28 and the lower plate 21, and the plastic beads 26 having a high compressibility and a little thermal deformability are in charge of forming a gap of a screen display part. In a terminal leading area 22, even if the glass fiber is used, the above problem is not caused because there is neither cross-over part of the scan line nor the signal line and TFT. Further, it is possible to make the best use of advantage that the gap forming performance of the glass fiber is superior to that of the plastic beads. That is, Fig. 3 shows an example of examining the gap space characteristic to the spacer dispersion density in the case of using the spacers of the glass fiber and the plastic beads having a diameter of 7 μm. It is found that while the plastic beads have the weak point in reproducibility of gap forming because the gap space has a large dispersion density dependency (a curve (a) in Fig. 3), with the spacer of the glass fiber, gap space with good reproducibility can be obtained at a dispersion density lower than that of the plastic spacer by ten times (a curve (b) in Fig. 3).

Fig. 4 shows a sectional view in the case where the plastic spherical spacers dispersed in the display screen part accidentally get on the a-Si TFT element part. In this case, since the plastic spacers has high compressibility and a little thermal deformability, the spacers which have been spherical before application of thermal load as indicated by a reference numeral 17 in Fig. 4 are deformed as indicated by a reference numeral 18 after application of thermal load to thereby prevent crushing of the TFT element. The use of spherical plastic beads can produce the effect of lowering the probability that the plastic spacer gets on the TFT element.

Fig. 5 is a diagram showing an example of a change in compressibility at the time of using the above plastic spacer material and applying load thereto one by one in a temperature range from -30°C to 200°C. A curve (a) is a compressive characteristic realized at a comparatively low temperature, and a curve (b) is a compressive characteristic realized at a comparatively high temperature. In the temperature range from -30°C to 200°C, shown is the compressive characteristic changing within an oblique line region between the

lower limit (a) and the upper limit (b) of the compressive characteristic. That is, it became clear from Fig. 5 that in the case of using the plastic spacer material showing the compressive characteristic such that when load of 20kg is applied, the compressibility is within the range of 10 to 20% at a temperature ranging from -30°C to 200°C, gap can be formed without crushing the a-Si TFT element.

It is found that as the plastic spacer material showing such compressive characteristic, a crosslinked copolymer mainly composed of di-vinyl benzene, polystyrene or benzoguanamine-formaldehyde condensation product is suitable.

Further, it is clear that it will be sufficient to use the plastic spacer material in the display screen at the dispersion density ranging from 30 to 100/mm^2, as shown in Fig. 3, and it will be sufficient to use the glass fiber spacer in the sealant in the range of 5 to 50/mm^2.

It goes without saying that the method of the invention is applicable to an active matrix type liquid crystal display panel as well, in which instead of the a-Si TFT, a-SiniP diodes are combined like a ring to have nonlinear characteristic.

[Embodiment]

The present invention will be described hereafter.

As shown in Fig. 4, on a lower glass substrate 1, a Cr gate electrode (scan line) 2 pattern with a film thickness of 0.1 μm, an SiN gate insulation film 3 deposited 0.3 μm thick by plasma CVD method using SiH_4-NH_3-N_2 gas, an a-Si:H(i) film pattern deposited 0.3 μm thick by plasma CVD method using SiH_4 gas, a drain electrode (a signal line) 5 formed of two layers: Cr 0.1 μm thick and Al 0.3 μm thick and a source electrode pattern 6 are sequentially formed to obtain an a-Si TFT matrix array. At the time, in manufacture, generally an a-Si:H (n) layer 41 is interposed in a contact part between the drain electrode and the source electrode and the a-Si:H(i). Subsequently, an ITO pixel electrode pattern 7 is electrically connected to the source electrode 6 corresponding to each pixel. An SiN passivation film 8, an Al shielding film 9 and an orientation film 10 are sequentially formed thereon to form a lower glass substrate.

On an upper glass substrate 16, as shown in Fig. 4, a color filter layer 15 of red, green and blue disposed corresponding to the respective pixel electrodes, a protection film 14 formed of organic resin, an ITO counter electrode 13 patterned to cover the whole surface of a display screen area, and an orientation film 10 are formed.

In positioning and sticking the upper and lower glass substrates to each other, as shown in Fig. 2, glass fibers 25 having a diameter of 8 μm are dispersed at a surface density of 8 to 20/mm^2 in a sealant 24 formed of thermosetting polyimide resin, and on a display screen part 23, plastic spherical beads 26 hawing a diameter of 8 μm made of a crosslinked copolymer mainly composed of vinyl benzene are dispersed at a surface density of 40 to 50/mm^2 to stick the substrates to each other. Subsequently, load of 1 kg/cm^2 at 150°C is applied to perform temporary curing for gap forming so that the space between the upper and lower substrates is fixed. At the time, in the case of using a thin film having dimensions of 12 cm x 15 cm, for example, it is necessary to uniformly apply load of 180 kg thereto. As shown in Fig. 4, however, in the case where the plastic bead 17 accidentally gets on a plastic bead 17, excessive pressure is applied to the beads and the TFT element part. In the method of the invention, however, since the plastic beads 17 have the compressive characteristic to be contained in the oblique line part in Fig. 5, the beads are deformed as indicated by the reference numeral 18, the TFT element is not crushed. Even in the case of a liquid crystal panel whose number of pixels in the display screen part is 640 x 600 = 384, 000 pixels, for example, when the glass fibers are used in the display screen part, breaking of the TFT element occurs at the probability of 10/380,000 pixels. In the case of the plastic beads, however, it is confirmed that the probability can be lowered to 1/380,000 or smaller. Further, as shown in Fig. 2, glass fibers 25 having favorable gap forming characteristic (Fig. 3) are used in a sealant 24 on a terminal wiring part 22, so the uniformity of the gap space between the upper plate and the lower plate can be obtained with good reproducibility.

Subsequently, after final curing for four hours at 130°C, liquid crystal (27

in Fig. 2, 11 in Fig. 4) is enclosed, and a driving circuit is attached to the periphery of the panel to finish an active matrix type liquid crystal panel module. When this liquid crystal panel is used for a liquid crystal color television set, a product having favorable characteristic without linear defect and uneven contrast ratio in the display screen has been obtained.

[Advantage of the Invention]

According to the invention, as described in detail in the embodiment, in the manufacturing method for a liquid crystal display device, the plastic spacer material having comparatively high compressibility is used in the display screen area where a number of a-Si TFTs are integrated at high density, whereby in applying thermal load to the upper and lower plates to stick the plates to each other, breaking of TFT due to the spacer material can be prevented, and further hard glass fibers having favorable gap forming characteristic are used in the sealant for sticking the upper and lower plates to each other at the terminal wiring part, so in-plane uniformity and reproducibility of the gap space are both superior. Accordingly, in the liquid crystal display device using the method of the invention, the effect of restraining uneven brightness in the display screen can be produced.

4. Brief Description of the Drawings

Fig. 1 is a sectional view of one pixel part of the conventional active matrix liquid crystal display panel;

Fig. 2 is a sectional view showing the arrangement of the spacer material in a liquid crystal display device according to the invention;

Fig. 3 is a diagram showing the characteristic showing the gap forming characteristic of the spacer material;

Fig. 4 is a sectional view of one pixel part of the liquid crystal display device according to the invention; and

Fig. 5 is a diagram showing the range of compressive characteristic of a plastic spacer material used in the invention.

1: lower glass substrate 2: gate electrode 3: gate insulation film 4: a-

Si:H (i) 41: a-Si:H (n+) 5: drain electrode 6: source electrode 7: ITO pixel electrode 8: passivation film 9: shielding film 10: orientation film 11: liquid crystal 12: glass fiber 13: ITO counter electrode 14: protection film 15: color filter 16: upper glass substrate 17: plastic space of initial shape 18: deformed plastic spacer 21: lower glass substrate 22: terminal wiring part 23: display screen wiring part 24: sealant 25: glass fiber 26: plastic spacer 27: liquid crystal 28: upper glass substrate

AMENDMENT (Voluntary)

March 11, 1994

Commissioner of the Patent Office

Designation of the Case:

Patent Application No. 56580/1987

Title of the Invention:

LIQUID CRYSTAL DISPLAY DEVICE

Person Making Amendment:

Relation to the Case: Patent Application

Name: (510) Hitachi Limited

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Object of Amendment:

Column of " Title of the Invention", column of "Claims" and column of "Detailed Description of the Invention" of the specification

Contents of Amendment:

1. The title of the invention is amended to "LIQUID CRYSTAL DISPLAY DEVICE".

2. The claims are amended as stated in the attached sheet.

3. "a manufacturing method" in front of "a device" in the nineteenth line on page 2 of the specification is deleted.

4. The following description is added to the end of the tenth line on page 4 of the specification. "JP-A-59-100487 (hereinafter referred to as prior art) is cited as the prior art to the invention. The prior art discloses that in a liquid crystal display device in which a transistor is formed in each of pixels, an elastic

plastic spacer material is used on a display screen area to prevent damage of a transistor substrate.

The prior art, however, did not mention the relationship in dispersion density between a plastic spacer material in the display screen area and a glass fiber spacer material in a sealant and the optimum value of compressibility in application of load."

5. The following description is added to the end of the second line on page 9 of the specification. "Accordingly, the dispersion density of the glass fiber spacer is lowered as compared with the dispersion density of the plastic spacer, whereby surplus glass fiber spacer can be saved to reduce the manufacturing cost."

Attachment

Claims:

1. A liquid crystal display device, comprising: a first substrate where a TFT and an ITO pixel electrode are disposed in each of a plurality of pixels on a translucent substrate; a second substrate where an ITO common electrode corresponding to each pixel is disposed on a translucent substrate; a spacer material for holding the gap space between the first substrate and the second substrate to a desired value; a sealant for sticking the first substrate and the second substrate to each other; and a liquid crystal layer provided in the gap between the first substrate and the second substrate, wherein the spacer material includes a first spacer material scattered between the pixel and the ITO common electrode and a second spacer material scattered in a part outside the space between the pixel and the ITO common electrode in the sealant, the first spacer material is formed of plastic having elasticity, the second spacer material is formed of glass fiber, and the dispersion density of the second spacer material is lower than the dispersion density of the first spacer material.

2. The liquid crystal display device according to claim 1, wherein the dispersion density of the first spacer material ranges from $30/mm^2$ to $150/mm^2$, and the dispersion density of the second spacer material ranges from 5 to $50/mm^2$.

3. The liquid crystal display device according to claim 1, wherein the first spacer material is formed of plastic whose compressibility in application of load of 20 kg ranges from 10% to 20%.

4. The liquid crystal display device according to claim 1, wherein the first spacer material is formed of thermally deformable plastic.

5. The liquid crystal display device according to claim 1, wherein the first spacer material is spherical.

別紙

特許請求の範囲

１．透光性基板上にＴＦＴおよびＩＴＯ画素電極を有する複数の画素部を配設した第１基板と、透光性基板上に上記各画素に対応するＩＴＯ共通電極を配設した第２基板と、上記第１基板と上記第２基板のギャップ間隔を所望の値に保つためのスペーサ材と、上記第１基板と上記第２基板を貼り合わせるシール材と、上記第１基板と上記第２基板のギャップ間に設けられた液晶層を有し、

上記スペーサ材は上記画素と上記ＩＴＯ共通電極間に散在された第１スペーサ材と、上記シール材中でありかつ上記画素と上記ＩＴＯ共通電極間を除く部分に散在された第２スペーサ材よりなり、上記第１スペーサ材は弾力性のあるプラスチックよりなり、上記第２スペーサ材はグラスファイバよりなり、上記第２スペーサ材の分散密度は上記第１スペーサ材の分散密度より少ないことを特徴とする液晶表示装置。

２．上記第１スペーサ材の分散密度は３０個／㎟から１５０個／㎟の範囲にあり、上記第２スペーサ材の分散密度は５個／㎟から５０個／㎟の範囲にあることを特徴とする特許請求の範囲第１項記載の液晶表示装置。

３．上記第１スペーサ材は２０kg加重時の圧縮率が１０％から２０％の範囲内に含まれるプラスチックよりなることを特徴とする特許請求の範囲第１項記載の液晶表示装置。

４．上記第１スペーサ材は感熱形性のプラスチックよりなることを特徴とする特許請求の範囲第１項記載の液晶表示装置。

６．上記第１スペーサ材は球形であることを特徴とする特許請求の範囲第１項記載の液晶表示装置。

【公報種別】特許法第１７条の２の規定による補正の掲載
【部門区分】第６部門第２区分
【発行日】平成６年（１９９４）１０月１８日

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手続補正書（自発）

平成 6年 3月 11日

特許庁長官 殿

事件の表示
昭和６２年　特許願　第　５６５８０号

発明の名称
液晶表示装置

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補正の対象　明細書の発明の名称の欄、特許請求の範囲の欄及び発明の詳細な説明の欄

補正の内容
１．発明の名称を「液晶表示装置」と補正する。
２．特許請求の範囲を別紙の通り補正する。
３．明細書第２頁第１９行の「装置」の後の「の製造方法」を削除する。
４．明細書第４頁第１０行の末尾に「なお、本発明の先行技術に特開昭５９－１００４８７号公報（以下先行技術）がある。先行技術には、画素の各々にトランジスタを形成した液晶表示装置において、画面領域上に弾力性のあるプラスチックスペーサ材を用い、トランジスタ基板のダメージを防止する点の記載がある。
しかし上記先行技術は、本発明の、画面領域内のプラスチックスペーサ材とシール材中のグラスファイバスペーサ材の分散密度の関係や、加重時の圧縮率の最適値に関する点については言及していない。」の記載を追加する。
５．明細書第９頁第２行の末尾に「従って、グラスファイバスペーサの分散密度をプラスチック製スペーサの分散密度よりも少なくすることにより、余分なグラスファイバスペーサを省くことができ、製造コストを下げる効果がある。」の記載を追加する。

以上